COUPP/PICASSO

Andrew Sonnenschein
Fermi National Accelerator Laboratory

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Picouppso?

- COUPP and PICASSO are merging in order to pursue a ton- scale superheated liquid experiment.
- Already gearing up on R&D tasks.
- New collaboration will have 60 physicists at 12 institutions in US, Canada, Spain, India, Czech Republic.
- We had our first joint collaboration meeting in February.
- We are in the first round of voting for a new name…. 91 entries on the ballot.

COUPP/ PICASSO Collaboration

First collaboration meeting, SNOLAB, Feb. 23 2013

Is your experiment currently operating, and with what total target mass?

- COUPP-4
  - Ran in 2011-2012 with 4 kg of CF_3I.
    1st run- Phys. Rev. D 86, 052001 (2012)
    2nd run- analysis in progress
  - Planning a low threshold run in 2013 with 2.6 kg C_3F_8 ("COUPP4-Lite")

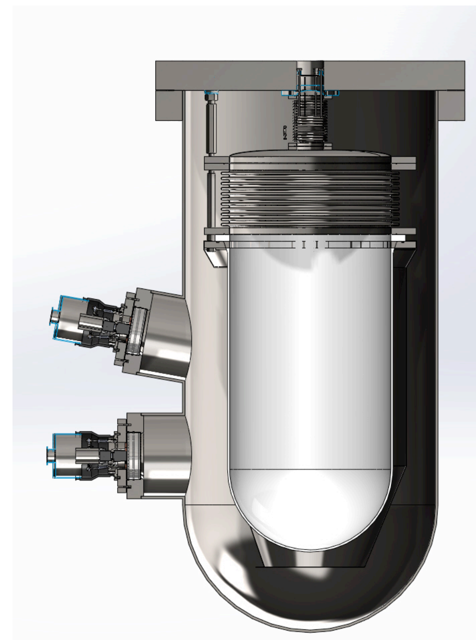
- COUPP- 60
  - Will run in 2013-2015 with up to 80 kg CF_3I.
  - First run with 40 kg CF_3I scheduled to start this month.

- PICASSO (see next talk)

What total target mass do you expect to have operating 10 years from now?

- COUPP/PICASSO will propose a ton-scale detector operating in ~2015-2018. This will be based on the R&D currently being done for COUPP-500 (bubble chamber) and PICASSO-500 (geyser).

- The next step would be an array of similar sized modules.



COUPP-500 Concept

Fiducial Target Mass

- For 2012 COUPP PRD result (4 kg detector), fiducial cut had an acceptance of 92%. We cut a 2 mm layer near the outside of the detector.
- For larger detectors COUPP-60, COUPP/PICASSO-500 inefficiency due to fiducial will become negligible.
- Combined acceptance of all fiducial, analysis and discrimination cuts was 80% in most recent publication. Live time fraction was 88%. We expect improvements for larger chambers.

Demonstrated Background Level- Before Discrimination, Improvements Needed

- The detectors are intrinsically blind to gamma interactions. We measure 10^5/kg-day with a NaI counter deployed inside the small COUPP-4 detector. Gamma fluxes in larger detectors will be suppressed by water shielding.
- Alphas: Demonstrated 4 alpha-decays / day in COUPP-4. Alpha-decay rate is expected to scale with the surface-area of stainless components, giving ~20 alpha-decays / day in COUPP-500. Reduction required for background-free one-year exposure ranges from none to x50, depending on alpha-discrimination.
- Neutrons (singles) 0.02 events/ kg-day in 2012 run with 15 keVnr threshold. Need to improve by 4 orders of magnitude through better radiopurity and shielding.

Discrimination

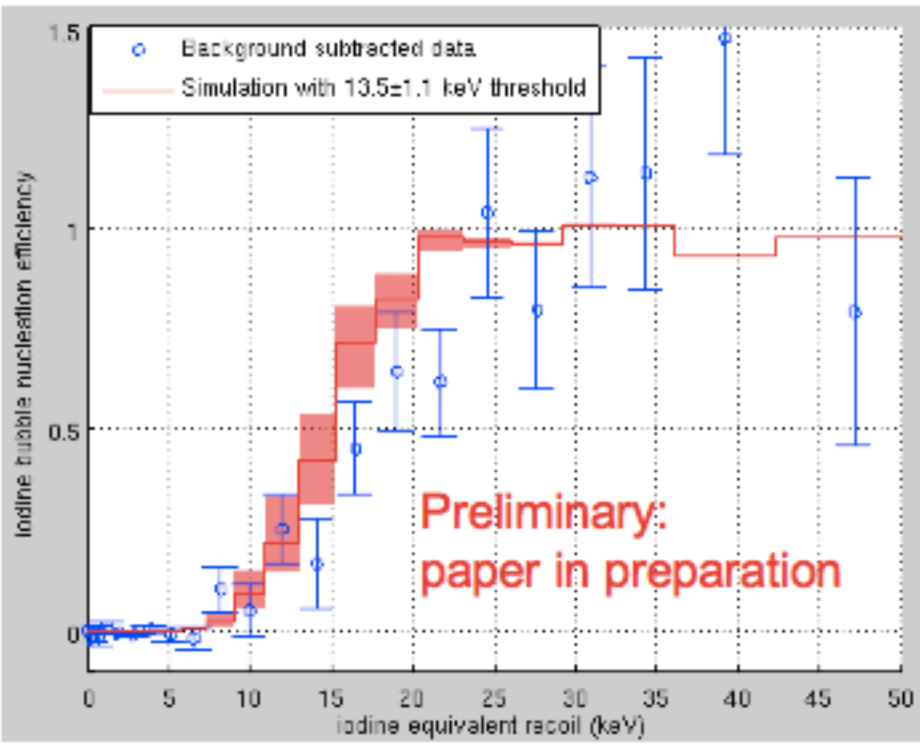
- Beta/gamma discrimination. <3 x 10^{-11} at 15 keVnr threshold. No improvement needed.
- Alpha discrimination: >99.3% demonstrated, but this measurement limited by neutron backgrounds. Discrimination failure may already be as low as ~10^{-5} (estimated fundamental limit). 10^{-4} is needed if no improvement is made to the projected 20 alpha-decays / day in COUPP-500.
- Neutrons. Multiple scatters are easily recognized given the fully active volume and 4 mm resolution of the detector. Multiples can be used to develop a precise estimate of singles contribution to background. No neutron veto detector currently planned.
- Mystery events. We saw a handful of anomalous recoil-like events in 2012 runs of COUPP4 at the lowest thresholds (7 keV and 10 keV). A subset of these exhibit time correlations and anomalous acoustic amplitudes. No such correlations have been seen above 15 keV. Large low-threshold exposures in COUPP60 will be needed to test competing hypotheses on the origin of these events.

Energy Threshold

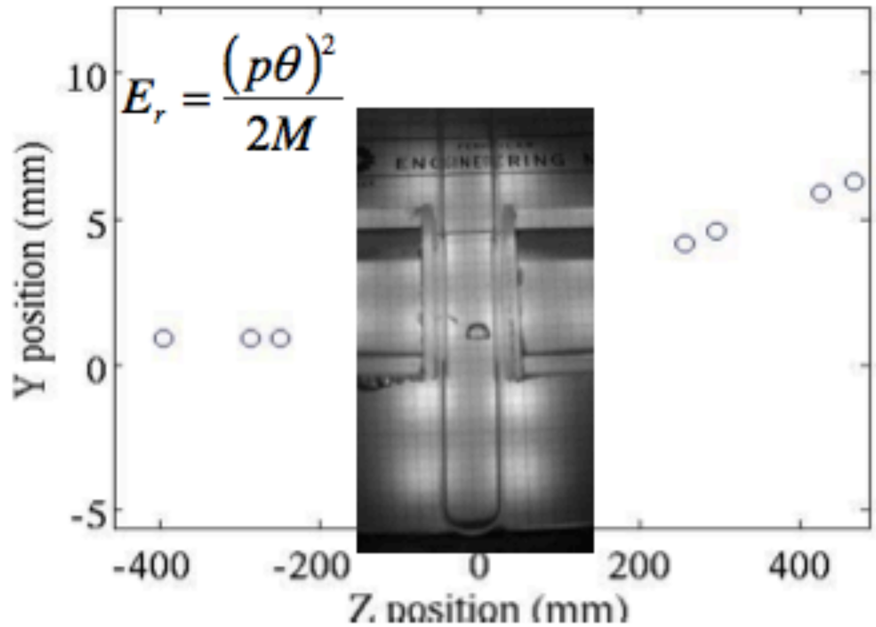
- We assume 15 keVnr for both iodine and fluorine recoils in CF_3I target liquid for most sensitivity estimation purposes.
- Stable operation has been achieved by COUPP in some chambers at 4 keVnr for CF_3I and at 3 keV in C_3F_8 . Picasso has achieved 1.7 keVnr in C_4F_{10}.
- CIRTE pion scattering at experiment at Fermilab has recently demonstrated sharp turn on of efficiency for iodine recoils in CF_3I (15 keVnr).
- Low energy neutron scattering experiments are in progress to improve understanding of fluorine recoil efficiency.

Nuclear recoil efficiency (iodine)

- Pion-scattering calibration of iodine threshold in CF_3I.



- 12GeV pion beam with silicon pixel telescope to measure scattering angle.
- Example event: 10mrad scatter, 56keV Iodine recoil.



Experimental Challenges & Required R&D

- Understand spurious “mystery events”. Need long, low-threshold exposures to accumulate a larger sample.

- Chemistry. Stability, purity, chemical compatibility.

- Low background materials, especially for acoustic sensors.

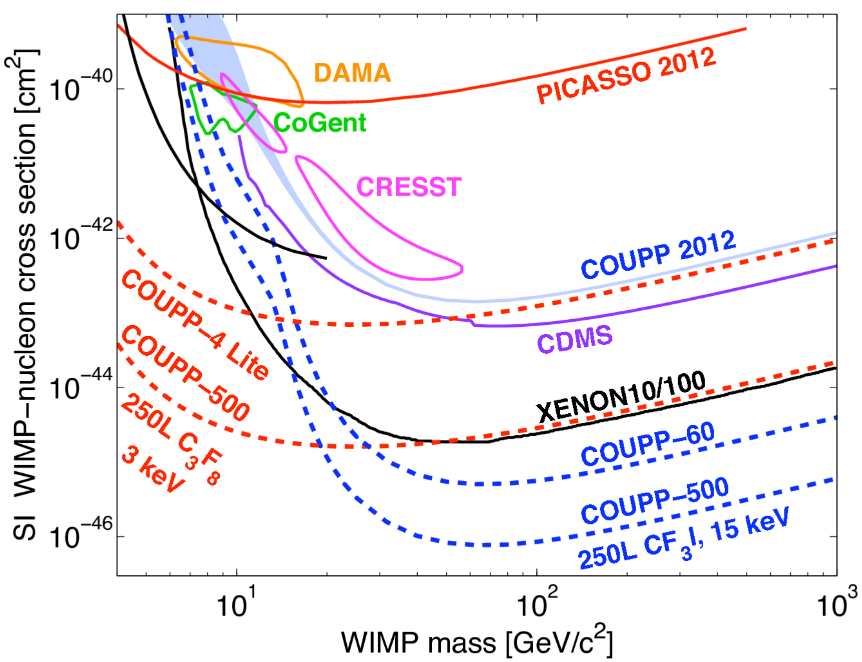
- Calibration work with neutrons and pion beams (CIRTE).

- Different fluids– CF2ClBr, CF3I, C3F8, CF3I, C4F10, C3H8, CF3Br.

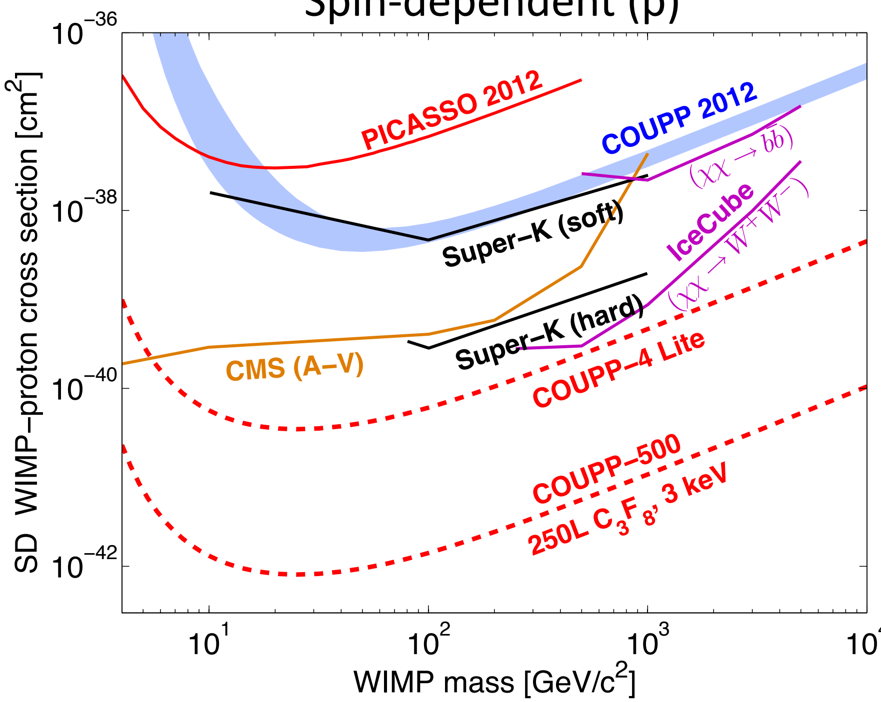
Sensitivity

• Blue results/projections are for CF_3I chambers. The blue bands indicate range of present threshold and efficiency uncertainties.
• Red results/projections are for low-threshold C_3F_8 chambers.
• Projections take 1 live-year with no candidate events except from coherent scattering of solar neutrinos (10 events in COUPP-500:C3F8).

Spin Independent



Spin-dependent (p)



Facility Requirements

- COUPP-4, COUPP-60 and Picasso are installed in SNOLAB “ladder labs”.
- Letters of Intent to SNOLAB submitted for COUPP/PICASSO-500. There are several possible underground locations. Likely would go in “cube hall” near MiniCLEAN and DEAP3600.
- Require 7 meter diameter water shielding tank.
- Emergency ventilation for target gas.

Unique Capabilities

- Bubble chambers can be made to operate with many liquids. Many interesting target liquids require no changes (CF2ClBr, CF3I, C3F8, CF3I, C4F10, C3H8, CF3Br). Other targets may require different temperature and pressure conditions than can be accommodated in current designs.
- Fluorinated target liquids give best sensitivity to spin-dependent interactions on protons– not matched by any other technique.
- If we see evidence for a signal, bubble chambers will have a unique capability to test the A^2 and spin dependence of the cross section. This will improve the discovery case and help identify the right particle physics model.
- Detection on multiple targets can be used to reduce astrophysical uncertainties in measurements of WIMP mass and cross section.